

BRIMAC BONE CHAR



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Who are Brimac Carbon Services



Who are Brimac Carbon Services

- Brimac Carbon Services is a UK Limited company which has manufactured Bone Charcoal in its site for over 150 years
- The manufacturing plant has a production capacity in excess of 5,000mt per year
- Brimac's main markets are the Sugar industry, Drinking water treatment and waste water / Effluent treatment.

What is Brimac Bone Charcoal

Bone char is produced by the calcination or "dry distillation" of cattle bones at temperatures approaching 1000°C in the absence of oxygen.

The material consists primarily of apatite II (hydroxyapatite) and approximately 10% elemental carbon with some carbonate arising from the formation of CaO during the ashing process and subsequent reaction with atmospheric CO₂.

Uptake of contaminants can occur via three processes. Firstly, species can become incorporated within the hydroxyapatite lattice substituting for Ca or CO₃. Secondly, species can interact with reactive groups on the surface of either carbon or hydroxyapatite (Physisorption and Chemisorption). Lastly free phosphate can form stable compounds with contaminants leading to their precipitation.

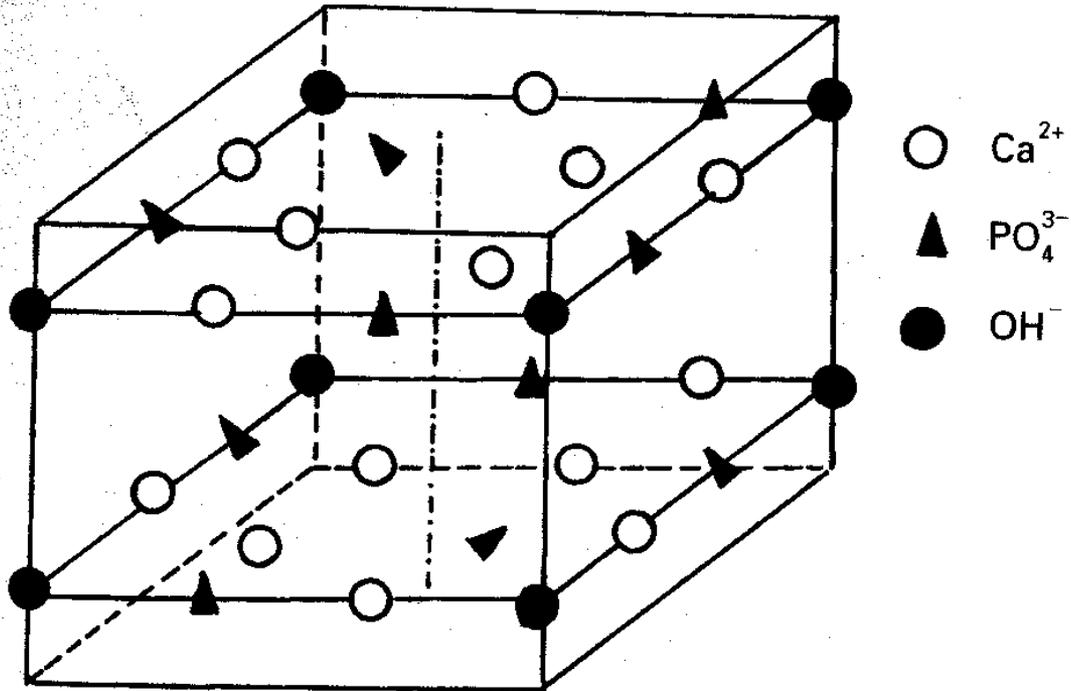
The material has found applications in the sugar and water purification industries as a cost effective and efficient means of removing trace impurities. The material has been shown to have a high adsorption capacity for a wide range of inorganic and organic contaminants including heavy metals. Bone char has also been used in the removal of radioisotopes from water.

What is Brimac Bone Charcoal

- **Composition** Hydroxyapatite (70-76%), CaCO_3 (7-9%)
Carbon (9-11%)
- **Moisture content** < 5%
- **Total surface area** 100m²/g
- **Carbon surface area** 50m²/g
- **Pore size distribution** 7.5-60000nm
- **Pore volume** 0.225cm³/g

Hydroxyapatite unit cell

(from Narasaraju and Phebe 1996)

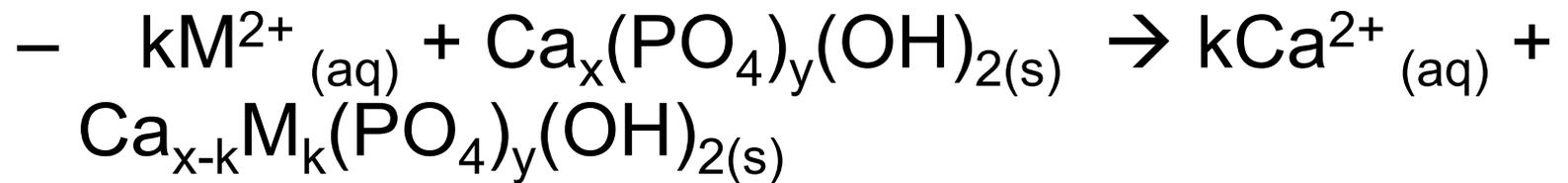


Hydroxyapatite unit cell

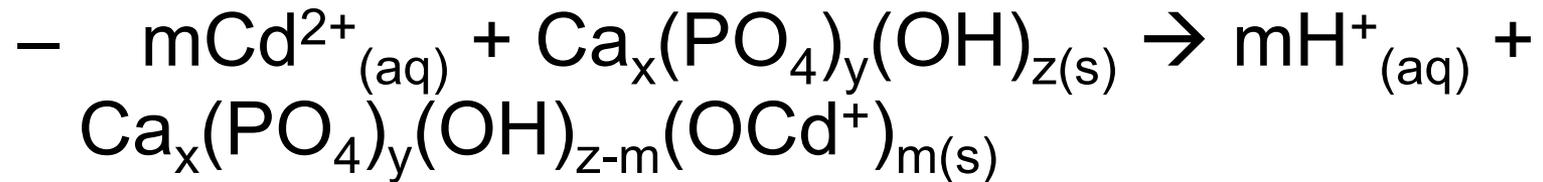
- Hydroxyapatite can exist over a range of calcium to phosphate ratios.
- After kilning, Bone char exhibits an average ionic ratio of 1.4 Ca to 1 PO₄ and as such it is described as a calcium deficient lattice.
- The amorphous structure of the calcium phosphate lattice is highly mobile, which leads to a high degree of ionic exchange within the lattice structure.
- The ability to incorporate other ions into the lattice is also influenced by the CaCO₃ content.

Examples of Sorption Mechanisms

- Ion Exchange



- Chemisorption



Metals Removed

| Metal | Capacity (mg/g) | Linear Velocity (m/hr) | Removal Efficiency (%) |
|---------------------|-----------------|------------------------|------------------------|
| <i>Aluminium</i> | 24 | 1 | >80 |
| <i>Arsenic III</i> | 30 | 0.5 | >80 |
| <i>Arsenic V</i> | 26 | 0.5 | >80 |
| <i>Cadmium</i> | 15 | 0.5 | >80 |
| <i>Chromium III</i> | 15 | 0.5 | >80 |
| <i>Chromium VI</i> | 8 | 0.5 | ~50 |
| <i>Copper</i> | 50 | 3 | >90 |
| <i>Iron</i> | 30 | 3 | >80 |
| <i>Lead</i> | 151 | 3 | >90 |
| <i>Manganese</i> | 50 | 3 | >80 |
| <i>Mercury</i> | * | 0.5 | ~50# |
| <i>Nickel</i> | 45 | 3 | >90 |
| <i>Silver</i> | * | 0.5 | ~50# |
| <i>Zinc</i> | 37 | 3 | >90 |

Other metals that can be removed are: Strontium, Uranium, Vanadium and radioactive metal compounds.

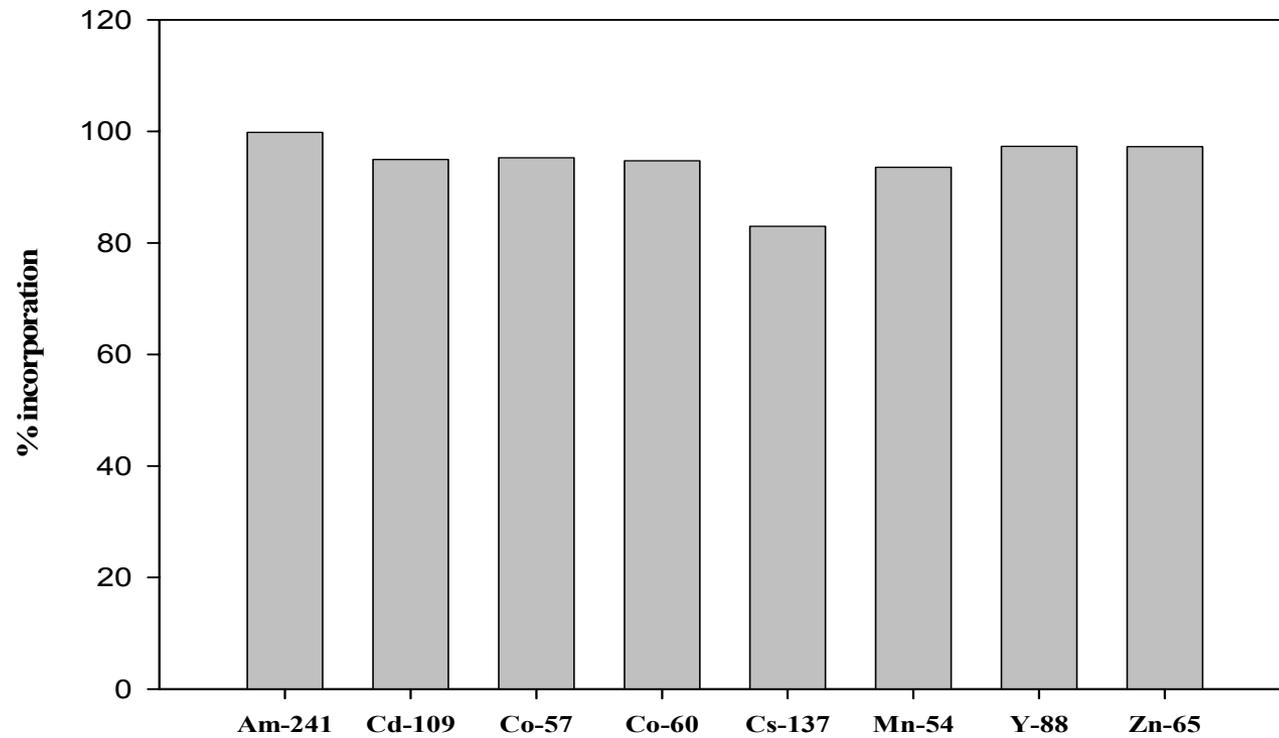
* - Undetermined capacity due to the nature of adsorption, does convert to pure metal from which recovery may be possible

#- Highly dependent on other species in the stream

All figures are subject to ongoing research and updating

Figures courtesy of Glasgow University

Incorporation of radionuclides



How is Brimac Char applied

- Brimac Water treatment Charcoal has been used in the UK Drinking Water market for over 15 years.
- It is a proven technology for difficult to treat raw waters in rural locations.
- The application of Brimac media is best suited to where coagulation technologies would be difficult to operate.

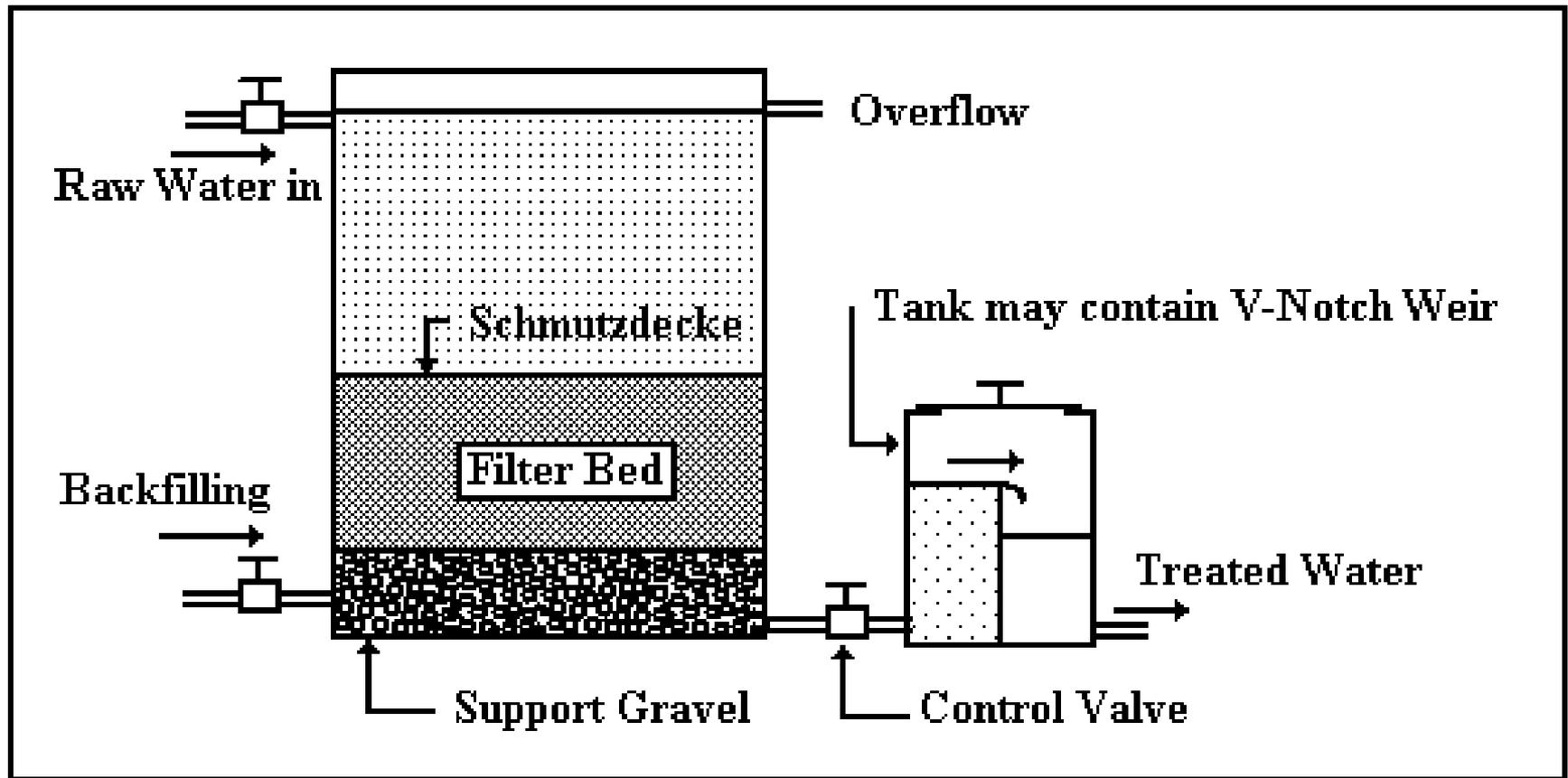
Q: How is Brimac media used

A: 1) Slow Sand Filtration

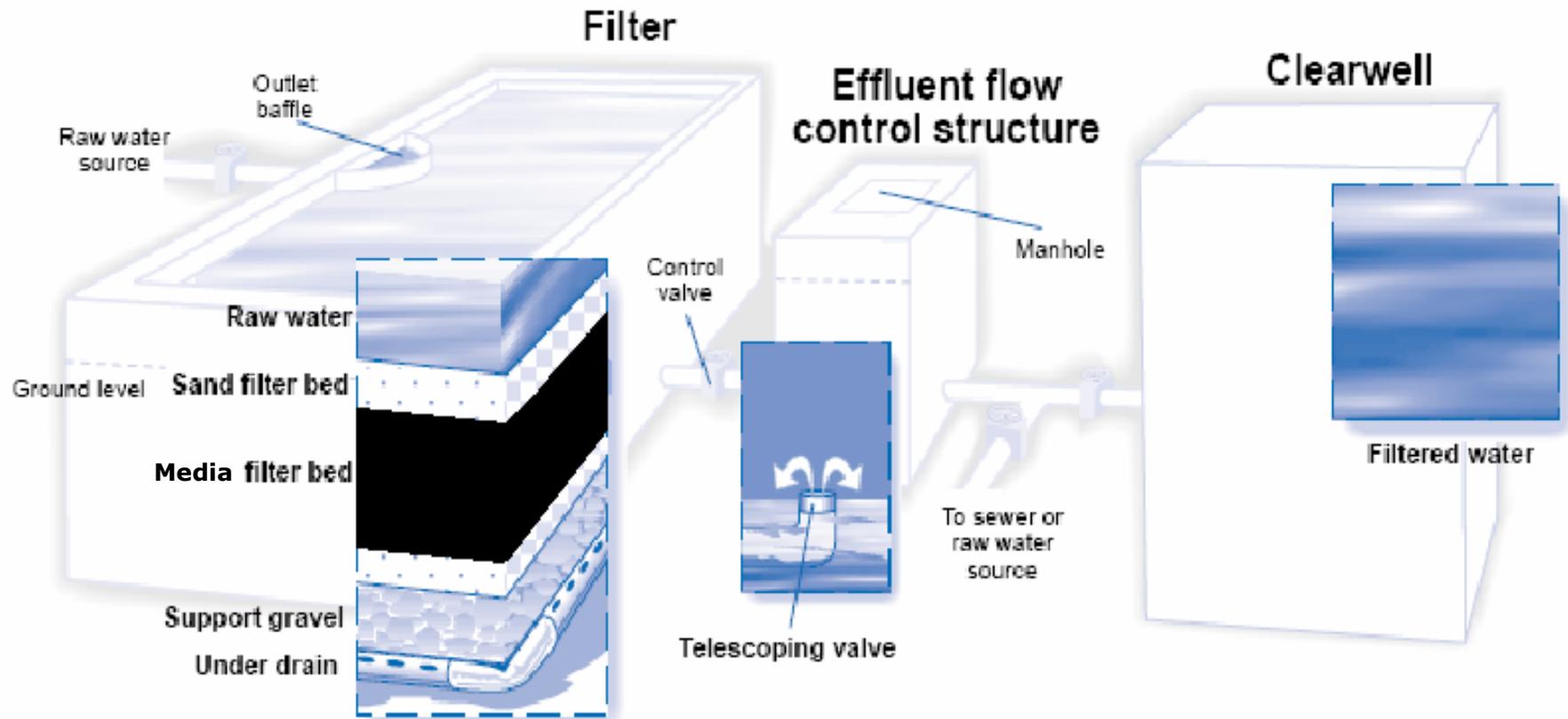
- Slow sand filtration is a simple, reliable process which combines turbidity removal with biological action to reduce pathogenic organisms, bacteria, cloudiness and organic levels in treated raw waters.
- With the addition of a media sandwich, slow sand filtration can significantly reduce heavy metals, pesticides and THM precursors.

Q: How is Brimac media used

A: 1) Slow Sand Filtration



Slow Sand Filter with media sandwich



Slow Sand Filtration Advantages

- Design & operational simplicity
- Minimal power and chemical requirements
- Minimal sludge handling
- Close operator supervision is not necessary
- Systems can make use of locally available materials & labor.

Even without a media sandwich, the slow sand filter still effectively removes many colloidal / suspended contaminates

Typical Treatment Performance of Conventional Slow Sand Filters

| Water Quality Parameter | Removal Capacity |
|--------------------------------|------------------|
| Turbidity | <1.0 NTU |
| Coliforms | 1-3 log units |
| Enteric Viruses | 2-4 log units |
| <i>Giardia</i> Cysts | 2-4+log units |
| <i>Cryptosporidium</i> Oocysts | >4 log units |
| Dissolved Organic Carbon | <15-25% |
| Biodegradable | |
| Dissolved Organic Carbon | <50% |
| Trihalomethane Precursors | <20-30% |
| Heavy Metals | |
| Zn, Cu, Cd, Pb | >95-99% |
| Fe, Mn | >67% |
| As | <47% |

Large Slow sand filter example, using a media mix of
Brimac Bone Char and GAC:

UK



Remote slow sand filter using Brimac media sandwich Isle of Barra, Scotland



Q: How is Brimac media used

A: 2) Pressure Vessel

- Combining the benefits of sand filtration and column adsorption, a dual pressure vessel system can provide the added benefits:
 - Ideal for small installations
 - Can be Fully Automated
 - Provides on demand treated water
 - Provides distribution pressure for Point Of Use type systems

This system does require maintenance and is dependant on power availability.

Q: How is Brimac media used
A: 2) Pressure Vessel

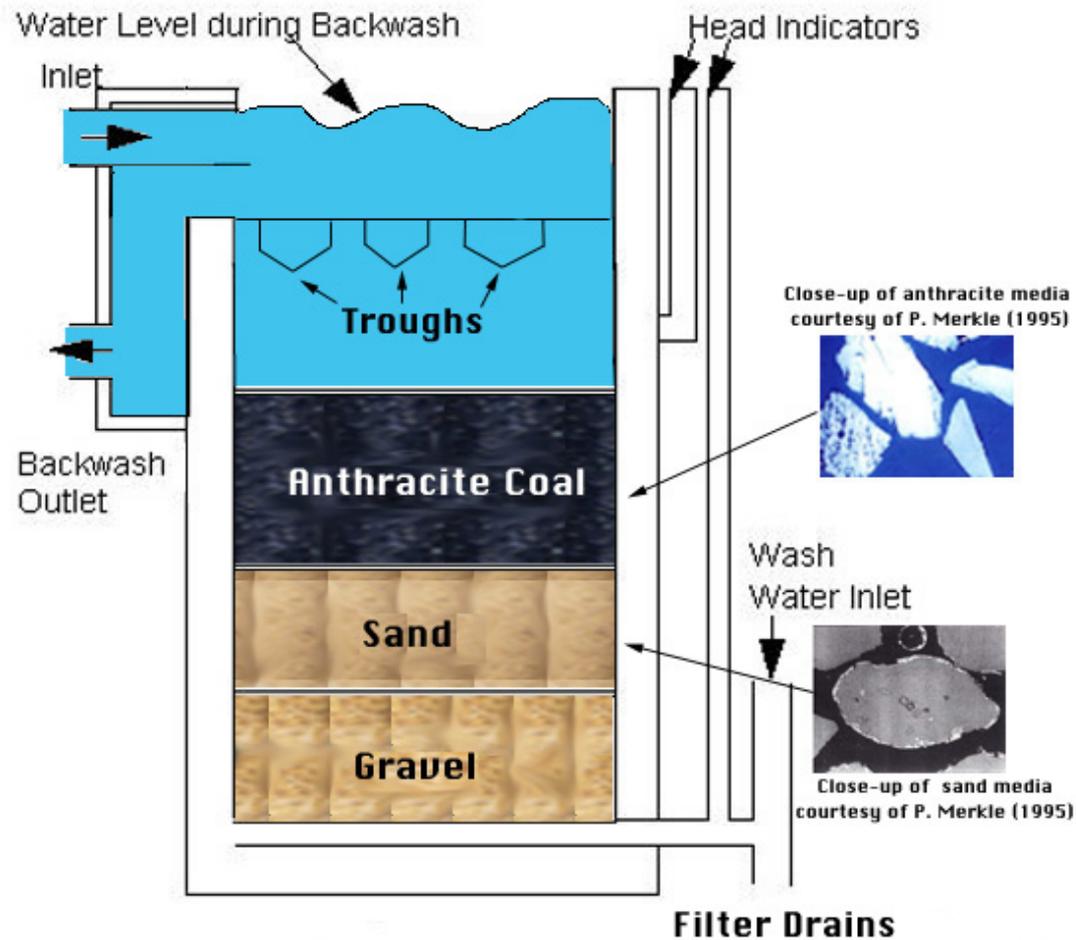


Q: How is Brimac media used

A: 3) Rapid Sand

- Rapid sand filtration is commonly used in municipal treatment works following coagulation.
- The operating limitations are well understood.
- This system can be augmented by large grist Brimac Char to provide polishing removal of heavy metals.

Q: How is Brimac media used
A: 3) Rapid Sand



The Application of Bone char to Arsenic removal.

- In a typical pH range for natural waters (pH 5-8) the species H_2AsO_4^- , HAsO_4^{2-} and H_3AsO_3 will dominate.
- All forms of Arsenic (Arsenite (III) & Arsenate (V)) are removed from water by char.

Bone Char Sorption of Arsenic

- Arsenic exchange with PO_4 has been suggested as a mechanism of sorption (Narasaraju, 1996). However only IR spectroscopy has shown any differences in PO_4 groupings as PO_4 has not been observed in any equilibrium solutions to any extent. The fact that CaCO_3 is formed from the reaction products suggests that perhaps exchange with CO_3 occurs.

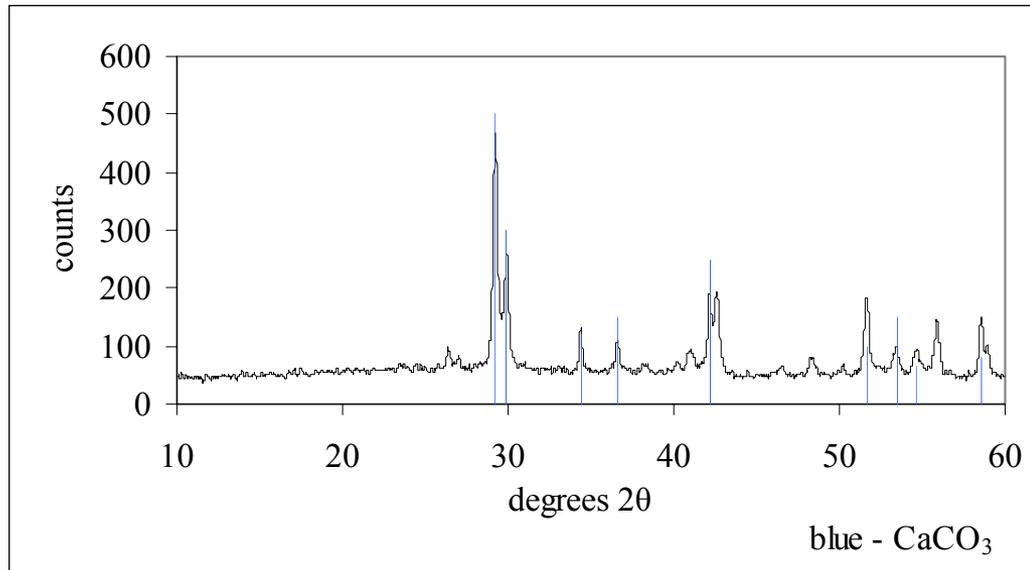


Figure 7.9 Reaction products from arsenic sorption onto bone charcoal

Advantages of Brimac Bone Char

- High capacity for large organic molecules (humic & fulvic acids), which are known to contribute to THM post disinfectant by-products.
- Simple application, the granular media can be utilized in a number of conventional treatment technologies.
- Broad spectrum adsorption of heavy metals, radio nucleotides and organic contaminants.
- Excellent at removing taste & odor from difficult raw waters
- Minimal water loses, only filter backwash water is discarded.